Should we use email for farm surveys? A comparative study of email and postal survey response rate and non-response bias

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1. Introduction: non-response and non-response bias in farm surveys

Ensuring a survey is both unbiased and representative is a critical objective for quantitative rural and agricultural research. Non-response and non-response bias is a particular problem that occurs when non-respondents to a survey systematically differ in terms of their response to key survey measures, leading to bias in those measures (Hall et al., 2013). Non-response bias can be caused by the use of a sampling frame that, in a non-homogeneous population, excludes a particular category of respondents. For example, Burton & Wilson (1999) observed that farmers not listing themselves within the Yellow Pages business directory were more environmentally oriented. However, non-response bias also commonly occurs when a sampling frame is representative, but particular sectors of respondents fail to either respond to the survey at all or are unwilling to respond to particular sections of the survey they might (more than others) consider as sensitive. For example, Coon et al. (2019) observe that the influence of non-response bias in environmentally-focused rural surveys is of particular concern because of respondents' fear of outside interference in land management.

Assessing who has not responded to a survey and why is problematic because, as it is generally not possible to obtain feedback from non-respondents, it is exceedingly difficult to draw firm conclusions on non-response biases and thus "there can be no certainty about the consequences of having missing data" (Nishimura et al., 2016, 59). The potential bias of non-responses to a specific survey is generally assessed using two main approaches. First, by comparing structural/demographic features of the sampled population with known census parameters of the wider population (e.g., farmer age, farm size, income, gender, and so on). In this case, it is assumed that the more similar the profile of respondents is to that of the census population, the less bias is likely as the sample is known to be representative on key structural/demographic criteria. While this is a common means of excluding bias (e.g. Woods et al., 2017), it does not guarantee identical responses to key survey measures in farmer surveys. Second, the survey response rate can be (and generally is) taken as a measure of the extent of non-response bias as

a sample with lower non-response rates is considered more reliable than one with higher non-response rates (Berg, 2005; Flicker, 2008; Weaver et al., 2019). However, while lower non-response rates provide less scope for serious non-response bias (Shih & Fan, 2009) they are a poor indicator of the quality of the survey as the information contained in the measure is extremely limited (Nishimura et al., 2016). In particular, response rates reveal nothing about the extent to which bias is present, in which population subgroups bias might be occurring, and/or which parts of the survey are subject to bias (Stedman et al., 2019).

For agricultural and rural surveys response rates are widely considered to be an essential measure of the quality of the population sample. However, the decline in response rates in rural surveys over the last decades has raised concerns about both the representativeness of samples and potential non-response bias (Coon et al., 2019). Young (2018), for example, observed that, over time, non-response bias caused by declining response rates has contributed to increased variability of crop forecasting models. Declining response rates have been noted across the social sciences. For example, in a longitudinal meta-study of social science surveys by mail (focused on natural resource-related topics–using relatively similar methods), Stedman et al. (2019) found an annual decline in response rates of 0.76% between 1971 and 2017 ($R^2 = .60$) and projected that, at this rate, by 2035 response rates to social science surveys (rural or otherwise) will be just over 20%. These low response rates provide the potential for biased sample returns and, consequently, attention needs to be paid to identifying means of maintaining or enhancing the response rates to surveys.

The cause of this decline is unknown. Coon et al. (2020) suggest demographic trends (in particular, aging populations in rural areas) and increased survey loads (particularly for farmers) both contribute to declining response rates to farm surveys. Declining response rates can have real effects on the outcomes of research. In terms of non-response bias within sampling frames, changes in modes of communication (in particular, the advent of email and social media) can also play a role in eliciting bias. This has been observed in the past. For example, in the 1980s Clark and Gordon (1980) contended that samples drawn from a telephone directory were likely to underrepresent small- and part-time farmers because of the cost of telephone communication. At this time, therefore, the sampling frame would have systematically overestimated the views of larger commercial farmers. By the mid-to late-1990s, however, Burton and Wilson (1999) observed that the cost of owning a phone line and listing as a business in the Yellow Pages was significantly lower and thus the sampling frame would be more complete.

New modes of communication can also affect non-response bias in sampling frames. For example, the arrival of mobile phones was found to provide a better way to reach mobile respondents than landlines or postal surveys (Sønvisen et al., 2011). Later, smartphone technology provided farmers a means of accessing the internet and email but have been found to systematically exclude older, less educated, and less computer literate farmers (Michels et al., 2020). Email surveys were initially focused on populations known to have both access to communication technologies – for example, university students, university employees, professional staff, or government employees – and computer literacy (Shih & Fan, 2009; Fan & Yan, 2010). However, recent years have seen dramatic increases in the number of computer users. In Norway, as with many other economically developed countries, internet usage increased considerably in the early 2000s as the number of people with access jumped from 64% in 2005 to 82% to 98% by 2019 (OECD, 2021). As a result, the potential use of email as a means of contacting survey respondents has both increased dramatically and extended beyond niche populations – although there are concerns that the changing role of computers from work tools to recreational (gaming) uses may mean that sectors of the population remain unresponsive to email surveys (Silva & Duarte, 2014).

Despite the increasing use of web and email surveys and a considerable body of research conducted into response rates for email surveys (see Shih & Fan, 2009 for a meta analysis) the issue of how vulnerable the approaches are to non-response bias requires further research (Coderre et al., 2004; Manfreda et al., 2008; Bonnichsen & Olsen, 2016). Some studies have suggested that data gathered in open-ended questions by phone surveys, mail surveys, and email surveys are of similar quality (Coderre et al., 2004). However, these authors note that their survey involved simple questions and that more complex forms of qualitative investigation may show higher levels of measurement error. In another study involving quantitative analysis, Bonnichsen & Olsen (2016) found that non-response bias occurred in web-based contingent valuation surveys looking at environmental non-market goods. In general, while there is overwhelming evidence that web-based or email surveys elicit lower response rates than conventional postal surveys, for agricultural studies, comprehensive research into non-response bias is almost non-existent.

In this study we look at the differences in non-response bias between postal surveys and email-based surveys by examining the 2018 version of the biennial survey “Trends in Norwegian

Agriculture" (referred to as the 'Trends' survey) sent to a statistically representative sample of farmers across Norway. As the result of a steady decline in response rates since 2004 (with one significant anomaly in 2012), we sent identical Trends surveys to respondents in 2018 using two different approaches – the traditional mail out survey and a web-based survey based on email contacts. This provided us with a unique opportunity to study the differences in response rates and potential non-response bias using both the old postal survey and a more contemporary online survey approach. The paper reports the results of the study in five sections. Following this introduction to the issue in Section 1, Section 2 outlines the methodology used in the study. This is followed by an analysis in Section 3 of the results of the survey comparing returns from the postal and email surveys. In Section 4 we then discuss the implications of the results for the use of email/web surveys in future agricultural studies and, in Section 5, present a brief conclusion on the basis of our findings.

2. Study design and method

2.1 Postal and email-based sampling for the Trends survey

Data analysed in this paper come from the survey 'Trends in Norwegian agriculture 2018', a nationally representative survey of Norwegian farmers that has been conducted biennially since 2002 (see e.g. Rye et al., 2002; Vik, 2008; Zahl-Thanem, et al., 2018; Zahl-Thanem and Melås 2020). Samples are drawn from the population using the Register of Producers at the Norwegian Agricultural Authority, which contains details of every farmer applying for production subsidies in Norway (i.e., almost all farmers). In the survey, farmers are defined as persons managing a farm with at least 0.5 ha of farmland, a criterion that excludes approximately 5 percent of the circa 40 000 Norwegian farms. The survey is distributed to 3000 farmers, constituting the gross sample.

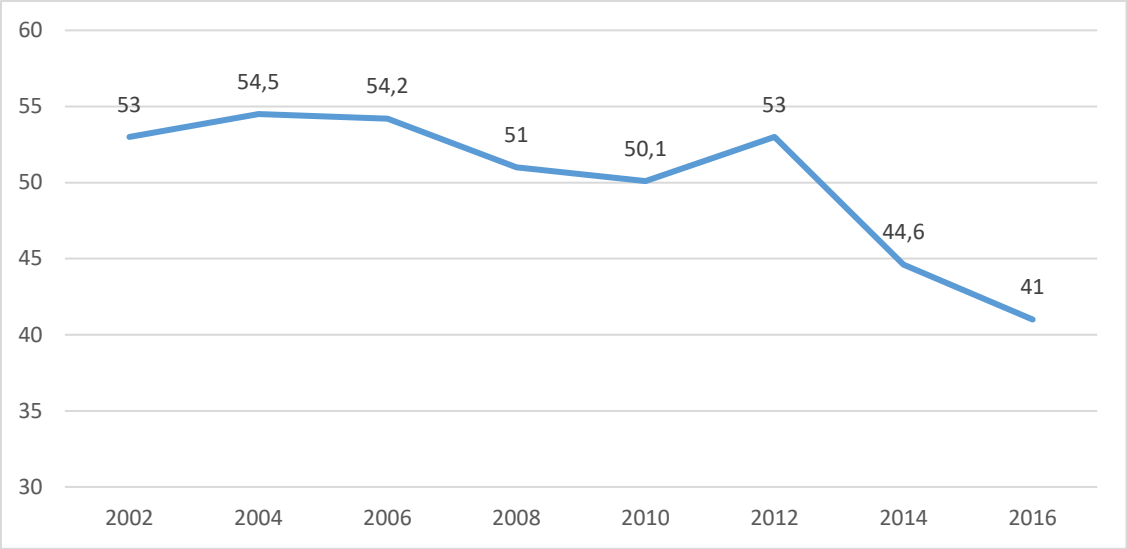

Figure 1. The response rate (in percent) of the biennial study from 2002 to 2016.

Between 2002 and 2016, the survey questionnaires were administered to respondents as a postal survey, although an electronic version of the survey was also made available to respondents in the past three distributions (2012, 2014, 2016) through a web link in the invitation letter (on paper). The information letter contained information about the survey, the organisation that commissioned the survey, and how the data and questionnaire will be administered in accordance with GDPR. Additionally, participating farmers had a chance of winning a travel gift card to the value of approximately 500 to 1000 euros.

During the first 10 years of the study, the response rate was relatively high for agricultural surveys (i.e., > 50 percent response rate). However, since 2012 a decline has been observed. Figure 1 shows a declining but relatively stable response rate of above 50 percent until 2012, but then decreasing rapidly to 45 percent in 2014 and 41 percent in 2016. There has been no change in the design of the survey (other than replacement of some questions) over the period and the survey has been distributed to a selection of the same population using the same selection criteria. While the opportunity to answer online through the web link was included as of the 2012 survey (response rate: 53 percent) there is no evidence to suggest that this inclusion was responsible for the decrease in the response rate.

For the 2018 survey we followed the standard practice of distributing 3000 paper-based questionnaires to farmers by post, but, this time, simultaneously sent out 3000 emails containing

a link to a web-based survey[1]. Thus, a total of 6000 unique names/farmers received the invitation to participate in the 2018 survey either by post or email. The two surveys and introductory letters were identical with the exception that some minor changes were necessary concerning how to respond (postal or online). The surveys were sent out simultaneously as sending out questionnaires to farmers in different periods has been shown to elicit bias (Pennings et al., 2002). Both the postal and email survey was distributed, collected, and scanned by a respected commercial survey organisation (Sentio Research Norge). This full-service research company has had many years of experience conducting different types of social science research – including email surveys – for actors in the academic, public, and private sectors.

2.2 *Questionnaire construction and content*

The 2018 Trends survey instrument comprised 12 pages of questions and required approximately 30 to 40 minutes to complete. A considerable amount of information about farmers and farms in Norway is gathered including demographic data on the farmer and farm family, characteristics of the farm itself, future plans for farm and farm family development, the economic condition of the farm, and farmers' attitudes towards a variety of topics of relevance to contemporary agriculture. Questions are closed format and use a combination of Likert-type scales, multiple choice (single answer), and multiple-choice (multiple answers) formats. In order to facilitate comparison over the years, changes to question format have been limited to those considered essential (due, for example, to changing economic context or problems with question interpretation) – thus the questions have been thoroughly tested and are known to be unproblematic.

2.3 Selection of variables for comparison

Given the lengthy nature of the questionnaire, it was not possible to present all the available data in this paper. Instead, we conducted a comprehensive review of all variables – using statistical tests to identify differences between the samples – and selected a number of variables

[1] The Register of Producers has an email coverage of 83.4 percent of the population of farmers – a coverage that increases annually.

for comparison. In addition, we examined several variables commonly included in agricultural surveys to represent farm or farmer characteristics – specifically; gender, education, age, full-time or part-time employment, presence of a successor, investment plans, farm size, and production type. These represent standard questions that enable researchers to identify farmer and farm characteristics likely to influence other aspects of decision-making (e.g. environmental decision-making – Wilson, 1996; Burton, 2014). In addition, we identified three key issues for contemporary agricultural research, namely; technology orientation, climate change attitudes and response, and attitudes to agricultural policy. In order to examine potential non-responses, we compared the characteristics of the respondents and their farms in both samples with known population characteristics from the national agricultural statistics where available.

The data used in our comparative analysis were measured in the following manner:

Demographic characteristics. Gender was coded as a dummy variable, with women assigned the value 1 and men the value 0[2]. *University education* is a dummy variable where farmers with a university-level education were coded 1 and farmers without a university education coded 0. *Age* was coded as a categorical variable into four groups: 'Under 40 years', '40-49', '50-59', '60-69', and '70 year or older'. *Full-time farmer* was coded as a dummy variable, with no paid work outside the farm coded 1, and paid work outside the farm coded 0. *Farm successor* was a dummy variable based on the question: 'Do you think someone in your family is going to take over the farm after you?'. Farmers answering 'yes' to this question were assigned the value 1, and farmers answering 'no' and 'don't know' were assigned the value 0. *Investment plans* is a dummy variable, with farmers planning to invest over 100 000 NOK (around 9 000 Euro in 2020) in either farm buildings, machines, or 'other' within the next five years coded 1, and farmers without such plans coded 0.

Farm characteristics. *Farm size* was coded as a categorical variable into four groups: below 5 ha, 5-9.9 ha, 10-49.9 ha, and 50 ha or greater. Additionally, type of production on the farm was based on register data of the respondents retrieved from the Register for Producers, where

[2] Gender is increasingly recognised as a non-binary construct. Future versions of the survey will contain an alternative category, however, because traditional gender identities are strong in agriculture (Shortall, 2014) we do not anticipate many would have identified themselves outside the binary choice.

farmers with one or more of the livestock types were coded 1 and farmers without the livestock coded 0. This applied to dairy, cattle, sheep, and pork production.

Technology orientation, climate change orientation, and agriculture policy preference. This part of the assessment was based on responses to attitudinal questions. Technology orientation was assessed using three questions from the survey, namely; perceived IT competence, attitudes to robotization, and attitudes to precision-farming. *Percevied IT competence* was based on the question: 'How competent are you on the farm within the following areas: 'Computer and IT'. The question was measured on a scale from 1 (very poor) to 5 (very good). Measurement of attitudes to *robotization* and *precision farming* were based on the following question: 'Do you think the following factors will have a negative or a positive effect on Norwegian agriculture?' – which had "robotization" and "precision farming" as response options measured on a scale from 1 (very negative) to 5 (very positive). Farmers answering 'don't know' were coded 3.

Climate change orientation was assessed using two variables. *Too high emissions from Norwegian agriculture* was based on the statement "Emissions of greenhouse gases from Norwegian agriculture are far too high" and measured on a Likert-type scale from 1 (strongly disagree) to 5 (strongly agree). *Agriculture's climate challenges are being taken seriously* was based on the statement: "Agriculture's climate challenges are being taken seriously in Norwegian agriculture" and was measured on a Likert-type scale from 1 (strongly disagree) to 5 (strongly agree). *Agricultural policy preferences* were measured using the question 'Do you think that Norwegian agriculture should prioritize the following tasks less, more, or the same as today?' and was based on the responses: *Secure settlement in the districts, Ensure cost-effective food production*, and *Ensure increased value creation.* These three variables were measured on a scale from 1 (prioritize to a lesser extent) to 5 (prioritize to a greater extent).

3. Results

3.1 Response rate

From the 6000 questionnaires distributed, a total of 2007 completed forms were returned: 1232 of 3000 from the postal survey and 642 of 3000 from the email survey (see Table 1). Thus, the overall response rate to the postal survey was 41.1 percent, while the response rate to the email

survey was 21.4 percent. Out of the 1232 farmers replying to the postal survey, 195 respondents chose to answer using the web link in the invitation letter. In the email survey, 757 farmers (25.8 percent) began to answer the questionnaire, but 115 did not complete the survey.

Table 1. Response rate of the postal and email samples.

Postal sample				Email sample			
		Frequency	Percent			Frequency	Percent
Valid	Answered	1232	41.1	Valid	Answered	642	21.4
	Did not answer	1718	57.3		Did not answer	2296	72.1
	Total	2950	98.3		Total	2938	97.9
Missing	Undeliverable	48	1.6	Missing	Undeliverable	60	2.0
	Deaths	2	0.1		Not valid email-adress	2	0.1
	Total	50	1.7		Total	62	2.1
Total		3000	100	Total		3000	100

3.2 Respondents' profile

Table 2 shows how demographic and farm structural characteristics varied between the postal and email samples, and their distribution compared to the population means. The confidence interval shows whether the population means fall within the estimated confidence intervals of the samples, while the test-statistic shows whether the sample means are significantly different from each other. As can be seen in Table 2, there are no gender differences between the samples, and the proportion of female farmers in the population falls within both samples' confidence intervals. As for the proportion of farmers with university-level education, the email/web sample received significantly more responses from respondents with a university degree. Although population data on Norwegian farmers' educational level is not available, the proportion of Norwegians in the general population with a university-level education is 33 percent (Statistics Norway 2018), indicating that university-educated farmers are somewhat overrepresented in the email survey.

Table 2. Comparison between the population, postal and email survey: Demographics and farm characteristics.

	Population means[2]	Postal survey	Email survey

Variables	Percentage with value 1	Percentage with value 1 (Std.Err.)	95 % confidence intervall	Percentage with value 1 (Std.Err.)	95 % confidence interval	Test-statistics (email vs. postal)
Demographic characteristics						
Female farmer (female=1, male=0)	16.2%	15.1% (0.01)	[13.0 - 17.1]	17.7% (0.02)	[14.7 - 20.7]	2.20 N.S.
University education[3] (yes=1, no=0)	N.A.	30.1% (0.01)	[27.5 - 32.7]	38.7% (0.02)	[34.9 - 42.6]	13.59**
Age categories						2.44*[1]
Under 40 years of age	18.1%	13.4% (0.01)	[11.5 - 15.3]	14.9% (0.01)	[12.0 - 17.8]	
Age 40-49	24.8%	21.3% (0.01)	[19.0 - 23.7]	24.6% (0.02)	[21.1 - 28.1]	
Age 50-59	29.9%	33.1% (0.01)	[30.4 - 35.7]	31.4% (0.02)	[27.6 - 35.1]	
Age 60-69	19.7%	23.9% (0.01)	[21.5 - 26.4]	23.4% (0.02)	[20.0 - 26.8]	
Age 70+	7.3%	8.3% (0.01)	[6.7 - 9.8]	5.8% (0.01)	[3.9 - 7.6]	
Full-time farmer (yes=1, no=0)	N.A.	29.5% (0.01)	[26.9 – 32.1]	24.7% (0.02)	[21.3 – 28.1]	4.70*
Farm successor (yes=1, no=0)	N.A.	67.3% (0.01)	[64.6 – 70.0]	65.5% (0.02)	[61.7 – 69.2]	0.62 N.S.
Investment plans (yes=1, no=0)	N.A.	61.1% (0.01)	[58.4 – 63.9]	69.2% (0.02)	[65.6 – 63.9]	11.6**
Farm characteristics						
Farm size						5.10 N.S.
=< 5 ha	10.6%	11.7% (0.01)	[9.9 - 13.6]	12.7% (0.01)	[10.1 - 15.3]	
5 - 9.9 ha	17.1%	18.1% (0.01)	[15.9 - 20.2]	14.4% (0.01)	[11.7 - 17.1]	
10 - 49.9 ha	60.1%	56.0% (0.01)	[53.2 - 58.8]	57.4% (0.02)	[53.6 - 61.3]	
=> 50 ha	12.1%	14.2% (0.01)	[12.2 - 16.1]	15.5% (0.01)	[12.7 - 18.3]	
Production on farm						
Dairy (yes=1, no=0)	19.8%	23.6% (0.01)	[21.2 - 26.1]	23.1% (0.02)	[19.8 - 26.4]	0.06 N.S.
Cattle (yes=1, no=0)	34.6%	35.8% (0.01)	[33.1 - 38.5]	36.4% (0.02)	[32.7 - 40.2]	0.07 N.S.
Sheep (yes=1, no=0)	36.6%	36.9% (0.01)	[34.2 - 39.7]	41.7% (0.02)	[37.8 - 45.5]	3.95*
Pork (yes=1, no=0)	5.7%	5.2% (0.01)	[3.9 - 6.4]	6.0% (0.01)	[4.2 - 7.9]	0.60 N.S.

Notes.

1. *Test-statistics for age were obtained from t-test using age as continuous when comparing, while χ2 tests were obtained for all the other measures.*
   **p<0.05, **p<0.01, N.S. = Not Significant*
2. *Population data were collected from Statistics Norway 2018. N.A = No data available.*

[3] Supplementary analysis showed that the proportion of farmers with a university level education was also substantially higher among the 195 farmers who replied to the invitation letter via the web compared to those who replied on paper.

T-tests revealed that the mean age was higher in the postal survey than the email survey. Although the distribution of age in both samples followed the same basic pattern as that of the general population, some age groups were underrepresented while others were overrepresented. In the postal survey, farmers in the age groups below 50 years were underrepresented, while farmers above 50 years of age were overrepresented. In the email sample, farmers below 40 years were also underrepresented, while farmers in the age group 60-69 were overrepresented. The confidence intervals for the age groups 40 to 49, 50 to 59, and farmers above 70 years of age all fall within the population mean proportion.

As can be seen in Table 2, the proportion of full-time farmers (i.e., farmers without work outside the farm) was significantly higher in the postal sample than in the email sample. However, there was no significant difference between the samples in terms of the likelihood of the farmer having a successor. A greater proportion of farmers in the email sample report that they are planning to invest in the farm or production within the next five years.

There were no significant differences between the samples in terms of labour characteristics and farm size, although the largest farms above 50 ha were somewhat overrepresented in both surveys. The proportion of farmers with sheep in the email sample was higher than the proportion in both the postal sample and in the overall Norwegian farmer population. Farmers with dairy and cattle on their farms were somewhat overrepresented in both samples. Yet, sample comparisons with data from Statistics Norway should be interpreted carefully since the survey data and the data of Statistics Norway are not gathered at the same time, and the operationalization may contain small differences.

3.3 Respondents' attitudes toward technology, climate, and agriculture policy

Table 3 shows the respondents' attitudes toward technology, climate, and agriculture policy in the postal and the email sample. The table shows respondents' mean score on each question in both samples, while test statistics show whether mean differences between the sample were statistically significant.

Table 3. Respondents' attitudes toward technology, climate, and agriculture policy in the postal and email sample.

	Postal survey	Email survey	
	Mean (Std.Err.)	Mean (Std.Err.)	Test-statistics (email vs. postal)
Technology orientation			
IT competence (1=very poor, 5=very good)	3.40 (0.03)	3.52 (0.04)	2.61 **
Robotization (1=very negative, 5=very positive)	3.27 (0.03)	3.43 (0.05)	2.78 **
Precision farming (1=very negative, 5=very positive)	3.44 (0.03)	3.60 (0.04)	3.05 **
Climate change orientation			
There are too high emissions from Norwegian agriculture (1=strongly disagree, 5=strongly agree)	2.28 (0.03)	2.24 (0.04)	-0.76 N.S.
Agriculture's climate challenges are being taken seriously (1=strongly disagree, 5=strongly agree)	3.79 (0.03)	3.73 (0.04)	1.19 N.S.
Agricultural policy preferences			
Secure settlement in the districts (1=prioritize to a lesser extent, 5=prioritize to a greater extent)	4.39 (0.02)	4.28 (0.04)	-2.63 **
Ensure cost-effective food production (1=prioritize to a lesser extent, 5=prioritize to a greater extent)	3.49 (0.03)	3.48 (0.04)	-0.20 N.S.
Ensure increased value creation (1=prioritize to a lesser extent, 5=prioritize to a greater extent).	3.93 (0.02)	3.98 (0.03)	1.24 N.S.

*Notes. Coefficients, S.E. standard errors. Test-statistics were obtained from t-test. *p<0.05, **p<0.01., N.S. = Not Significant*

Farmers participating in the email sample had a higher self-reported IT-competence than farmers in the postal sample. However, supplementary analysis showed that this effect ceases after adjusting for the age differences in the sample. Further, there were differences between the samples regarding attitudes toward both robotization and precision farming. Farmers in the email sample believe that both robotization and precision farming will impact agriculture more positively than is the case for farmers in the postal sample. In this case, the differences remained significant after adjusting for the sample differences in Table 2.

There were no significant differences between the email and postal samples with regards to the two climate questions (Table 3). However, attitudes toward securing a settlement in the districts – i.e. preserving the Norwegian government's longstanding policies of maintaining rural populations – differed between the two samples. Farmers in the postal survey wished to prioritize securing a settlement in the districts to a greater extent than farmers in the email sample. Supplementary analysis showed that this difference is also significant after adjusting for the sample differences in Table 2. Finally, there were no differences in attitudes between

the samples regarding ensuring cost-effective food production and ensuring increased value creation, which besides food security, maintaining sustainable agriculture and securing settlement in the districts are key agricultural policy goals in Norway.

4. Discussion – should we use email for farm surveys?

The digitalisation of society is something Ricter et al. (2019) describe as a "megatrend", one that, despite some concerns that rural areas will lag behind their urban counterparts (e.g. Cowie et al., 2020) will invariably become as much a part of the future of rural areas as elsewhere. Ultimately, therefore, it is likely that the option of conducting large-scale postal surveys will simply cease to exist as alternative digital communication technologies take over. Mail-like options may still be available. In Norway, for example, the Digipost service – run by the Norwegian postal service (Posten) – provides options for companies or local authorities to send digital 'letters' to citizens registered to the service, rather than needing to send paper documents. As this also requires some level of IT skill (although no more than email), we may initially see similarities in non-response bias to those revealed in the survey – in particular, respondents being more educated than the general population. Eventually, however, with agriculture becoming increasingly dependent on technology, younger, better educated farmers taking over the farms, and digital communication becoming the norm, any difference in non-response bias between a postal survey and a survey using digital means (including email) is likely to diminish. In the short term, however, while there is a choice between postal and digital surveys, the results of this study are useful for those planning to conduct surveys of farming populations.

In particular, we identified that respondents to the email sample were younger, better educated, more likely to work off the farm, and more likely to plan to invest in the farm over the next 5 years. The email survey thus captures a younger, more dynamic sector of the population – the antithesis of the traditional aging farming population common in Norway and Europe (see Burton & Fischer, 2015) and arguably the future of agriculture. The question we discuss in this section is: what does this mean for the application of email and postal farm surveys in Norway and internationally?

An important question that arises here is: while the sample populations are significantly different in key areas from each other, do either of the survey approaches deliver a sample more representative of the general population than the other? Unfortunately, comparative national

population statistics are only available for the features of gender, age, farm size, and production. Of these: for gender, there is little difference from the national statistic (1.1% and -1.5% respectively), for age the email sample is overall slightly more representative of the national profile than the postal survey sample (a total for all age categories of 16.6% and 10.1% respectively), for the farm size the differences were similar (a total of the for all size categories of 8.3% and 10.9% respectively), and for the farm product type the email sample was slightly less representative of the national profile than the postal sample (5.5% and 10.5% respectively across the product categories), largely because sheep farmers were over-represented by around 5% (see Table 2 for figures). Based on these comparisons, there is little to suggest one survey method delivers a vastly more representative sample than the other – although this comes with the caveat that we could only compare a limited number of features.

For the features where we were unable to compare the national farming statistics the over-representation of respondents with a university-level education in the email survey is particularly notable. Here, whereas the proportion of Norwegians in the general population with a university-level education is 33 percent (Statistics Norway 2018) in our study 30.1% of the postal sample and 38.7% of the email sample had been educated at the university level. Given the strong relationship between education level and age (older farmers have lower levels of education) and over-representation by older farmers in the general population (57% of Norwegian farmers are over 50), it is highly likely that the figure of 38.7% for the email survey is considerably over-representative of the actual farming population. As education is a powerful explanatory factor in social science and has been found to influence a range of outcomes, this could potentially lead to non-response bias. In particular, education has been found to influence farmers' environmental attitudes and agri-environmental participation in many studies (Burton, 2014).

In terms of the attitudinal responses, attitudes towards technology appeared to be strongly influenced by the survey methodology, with both robotization and precision farming attitudes being significantly more positive for respondents to the email survey. This was expected because of the connection between email use and feeling comfortable with technology (Shih & Fan, 2009). However, despite the strongly significant relationship, the numerical differences between the two survey approaches were relatively small. The average score for attitudes to robotization in the postal survey (measured on a 5-point scale from 'very negative' to 'very positive' – see Table 3) was 3.27, while the average score for the email survey was 3.43.

Attitudes to precision farming showed a similar level of variation with a mean score of 3.44 for the postal survey and 3.60 for the email survey. Thus, although there are clear tendencies for respondents to the email sample to express more positive attitudes towards robotization and precision farming, there is little likelihood of an alternative conclusion being drawn should the postal survey alone have been used. In both cases, the responses were 'somewhat positive'.

This is not always the case in surveys. For example, Macnaughten (1995) used three introductory "cultural voices" (pro-development, pro-quietness, and pro-freedom) to deliberately bias the response to a study of attitudes toward countryside leisure. This resulted in differences between the groups in the magnitude of two whole points on the Likert-type scale, with responses on opposite ends of the scale. For example, the "pro-quietness" group showed a disagreement level of -1.15 ('disagree slightly' to 'disagree strongly') with the notion of developing new tourist facilities in the countryside, while the "pro-development" group had a positive attitude to development of 0.73 ('neither agree nor disagree' to 'agree slightly'). In the case of Macnaughten's study, therefore, very different conclusions would have been drawn depending on the survey received. However, for our study, the application of different survey approaches results in the same conclusion, i.e., that in general farmers are 'somewhat positive' towards robotisation and precision farming.

Another interesting result from our study is that the dramatic difference in response rates for the postal and email surveys does not appear to have led to a correspondingly dramatic increase in non-response bias. As noted above, a sample with lower non-response rates is widely considered to be more reliable than one with higher non-response rates (Weaver et al., 2019). Yet, for our study, while the email survey had a response rate of almost half that of the postal survey (at 21.4% and 41.1% respectively) there was no evidence of significantly greater non-response bias in the email sample. The differences detected can be considered to be generally small and, in our case, did not affect the study overall. In terms of attitudes, as we noted above, any scalar difference in attitudinal measures is so limited (even where significant) that, despite the dramatically lower response rate for the email survey, there appears to be no significant bias introduced. This is not even taking into account the number of non-significant results. Based on a comprehensive review of all variables in the survey, few attitudinal variables were significantly different. The conclusion we draw here is that there is little to suggest – in the Norwegian case at least – that the lower response rates associated with email surveys of farmers deliver a significantly more biased sample.

Thus, while Coon et al. (2020, 981) recommend that because many rural people are older, farm surveys should "exclude technology that could exclude this population" our Norwegian study suggests that avoiding digital communication technologies might make little difference to the outcome of the survey. However, it is important to note that, while Norway is a good example of a society that has gone through the digital transformation, many others are still in the process of transitioning. In this sense, Norway does not represent a 'typical' country. A 2017 OECD report observed that, over a number of key indicators, equitable access to the internet in Norway was higher than in the majority of OECD countries. Internet access in rural areas was 94.7% (2nd highest), the proportion of women with access was 97.4%, (4th highest) and the proportion of internet users with no formal education was 94.5% (3rd highest). Thus, while our study demonstrated a limited effect of non-response bias, this may not be the case in, for example, France (no formal education 68.3%, women 85.5%, and rural 77.8%) or Greece (no formal education 33.9%, women 67.1%, and rural 52.4%) (OECD, 2017). In Greece, whereas a postal survey might reach all potential respondents, the large discrepancy between internet users with no formal education (33.9%) and those with tertiary education (69.1%) suggests that any measures of attitudes that are heavily influenced by education would therefore also be biased.

The quality of email survey results will also depend on the proportion of farmers using email as a means of communication. Recent figures for Norway from 2019 suggest that 97.05% of people living in rural areas now have access to the internet at home (OECD, 2021) which suggests a high level of access to farming populations. This, however, is not certain. In Finland, while 93.06% of the population living in rural areas had access to the internet in 2019 (OECD, 2021) only 80% of Finnish farmers registered an email address with the Finnish Food Authority (Peltonen-Sainio et al., 2020). Eighty percent still represents relatively complete access. As a comparison, the Yellow Pages business directory – used in numerous studies of farming populations in the past (e.g., Beedel & Rehman, 2000; Lobley & Butler, 2010) – was found to have a 72% coverage for farms in a Bedfordshire study (England) and a 68% coverage for a study in the Cambrian Mountains (Wales) (Burton & Wilson, 1999). Thus, while access to farmers may be lower than access to the general rural population, email may still provide a more comprehensive coverage than some current sampling frames.

Another concern for the generalisability of this study concerns the return rate achieved. Although by the standards of the postal survey, a return rate of 21.1% for the email survey

seems rather poor, it is in fact on the high end for farmers in email surveys. Many studies of farmers have achieved even lower return rates. For example, 12% (Peltonen-Sainio et al., 2020), 14.8% (Higham et al., 2018), 16% (Steininger et al., 2012), and 17% (Röös et al., 2019 – using a combined approach of email and postal surveys). When return rates are as low as 12% we cannot be certain that non-response bias does not play a role. Thus, while our study suggests that email surveys do not necessarily lead to a more biased sample than a postal survey, this is not necessarily always the case. A further issue is that postal surveys of farmers can have similarly low response rates. Grolleau et al. (2020) for example, achieved a response rate for a postal survey of just 7.4% due, they contend, to a delay in distributing the questionnaire and the reluctance of French farmers to respond to environmental studies.

A major issue with email surveys is the risk either of respondents viewing the invitation as 'spam', or the invitation being classed as 'spam' by a spam filter – leaving potential responders not even receiving the invitation (Manfreda et al, 2008; Shih & Fan, 2009). To address this issue we used a respected research company (Sentio Research) who are experienced at conducting large-scale email surveys and are well known within Norway (including by farmers). The company employs a standard practice for contacting potential respondents to maintain a good reputation and thus achieve a consistently high level of deliverability. If an email was undeliverable, this information was obtained and recorded by the send-out software, resulting in 62 of 3000 email addresses being identified as undeliverable (Table 1). However, the send-out software was unable to identify whether emails had been opened or not and there are thus uncertainties concerning how many of the recipients actually opened the email.

Despite the evidence suggesting that the email survey provides a good alternative to postal surveys, there are two key reasons why selecting the postal survey with its higher response rate might be preferable. First, and most importantly, lower response rates make it necessary to increase the size of the gross sample to get a sufficiently large net sample to statistically represent the population – i.e., in our case, we would need to contact twice as many respondents. This creates potential problems with survey fatigue – a noted problem for farm surveys partly due to frequent government surveying (Glas et al., 2019). For biennial surveys such as the Trends survey, the regular surveying of a large proportion of the farming population could prove particularly problematic as increased fatigue over a large proportion of the population could contribute to steadily declining response rates (as we are already witnessing – see Figure 1). An additional problem would occur if certain groups within the population are more subject

to survey fatigue than others, as this could again enhance non-response bias. Thus, from this perspective, the higher response rate of the postal survey is deemed preferable.

Second, some studies have found that response rates *can* influence attitudinal responses. In one case, Pennings et al. (2002) sent out a survey concerning farmer use of advisory services in the U.S. but, having received a response rate of just 12%, sent out a shortened and simplified second survey – achieving, in this case, a response rate of 35%. The authors found that the reason for the higher response rate was that younger farmers with larger farms were more likely to have completed the second survey. As a result, the assessment of one of their key variables on a 9-point scale moved from 5.78 in the first survey to 7.00 in the second survey – a sizeable and statistically significant difference. This illustrates that the non-response bias problem with low response rates is not the response rate *per se*, but the fact that a particular group may have been omitted as a result of the way in which the survey has been constructed and/or distributed. Where the differences between this group and the main population is minimal (as was the case for technologically oriented younger farmers in our study) low response rates make little difference to attitudinal measures and, thus, to the conclusion of the survey. However, as in most cases, we do not know whether this is the case prior to commencing the survey, it is safer to select the survey approach known to have a higher response rate.

Using mixed-mode design is a popular and often recommended approach as it compensates for the weaknesses of each individual mode (see De Leeuw 2005). For example, sending out electronic forms to farmers and a reminder using a different type of mode (e.g., telephone or post) may increase the chance of reaching those who did not respond to the email invitation. Although different combinations can be used, one should consider the method and combination of modes carefully depending on the research question, context, and the population in question. In our case, farmers are more inclined to respond to traditional postal surveys than email surveys, which suggests the main send-out should be postal. A mixed-mode with follow-up using email or telephone to those not responding to the postal survey could enhance response rates. However, the number of reminders should be kept to a minimum, and in our case, we limited the number of reminders to one to avoid causing annoyance to recipients. This was particularly necessary in our case because, as a biennial survey of a relatively small population (38 633 farmers in Norway (Statistics Norway 2020)), we return regularly to the same respondents. Cross-sectional surveys or more irregular repeated cross-sectional surveys of larger populations could consider a more repetitive follow-up approach.

5. Conclusion

As communication technologies evolve it is necessary to continue to seek to understand the strengths and weaknesses of particular survey approaches to prevent problems caused by non-response bias. This study has contributed to this literature by comparing email and postal survey approaches to contacting respondents in Norway – a country that is at the forefront of access to digital technologies and thus an exemplar of how the digital future might look for agricultural surveys. At a time when we appear to be transitioning from physical postal systems to digital systems, this analysis is particularly important in order to establish the validity of using email/web-based approaches for surveys, thus enabling researchers to make informed choices about which sampling frame to employ while both options remain available.

Our concluding message is somewhat mixed. In terms of non-response bias, if the two samples are compared, there is clearly bias towards better educated and younger farmers within the email sample. However, the impact of this non-response bias on the survey results (and therefore on the choice of postal or email) appears to be limited for two main reasons. First, although the options for comparison were limited, where we were able to compare the email sample with national statistics for the general farming population, there was little difference between the two sampling approaches in terms of representativeness – they diverged from the general population in different ways, but to similar extents. Second, for the vast majority of attitudinal factors examined – including important issues such as climate change and environmental concern – there was no significant difference between the samples. Even for technology orientation where there was a strongly significant difference, this difference was so small that it would be very unlikely to lead researchers to reach different conclusions based on the different samples. It is important here to note that this similarity in response occurred despite concerns that the response rate for the email survey was almost half that of the postal survey (21.4% compared to 41.1%) – suggesting that lower response rates for email surveys do not necessarily indicate greater non-response bias. Taking all this into account, we contend that given a comprehensive and up-to-date email list can be obtained, representative samples of farmer populations can be obtained using email approaches.

However, the result of our experiment investigating the possible use of email surveys for conducting the Trends survey was the conclusion that we should continue with postal surveys

in the short term. Even though email surveys are much cheaper and easier to administer, we are concerned about two issues. First, as email surveys would require a gross sample double the size to achieve the same net sample, there is a real concern that a move to email might create a problem with survey fatigue in the population. This could ultimately lead to even lower response rates and potentially cause bias in itself if survey fatigue is more experienced by some groups in the population than others. Second, while we found little difference between the samples, there is, without question, less potential for non-response bias when the response rate is higher. Given that we have no *prior* knowledge of potentially excluded groups and the postal survey continues to be a reliable option (and is comparable to past surveys), it makes sense to continue with this approach. If postal response rates decline further in the future as new digital services begin to dominate in rural areas, this will need to be reconsidered.

Finally, we need to observe that, in terms of its applicability beyond Norway the study comes with certain caveats. In particular, while Norway provides a good example of a country with widespread and equitable digital access, many countries (even some within the OECD) may not yet provide the level of access required to make our findings applicable. The progressive digitalisation of rural areas will change this, but given the current advantages to continuing postal surveys (even in Norway) consideration needs to be given as to whether to apply an email approach on a country by country basis. Another issue is that the response rate to the email survey in Norway was relatively high, with farmers in Norway, in general, showing a higher response rate to farm surveys than in other OECD countries (Henriques et al., 2004 - cited in Grolleau et al., 2020). With response rates to email surveys in some countries approaching half that of our survey, it is difficult to ascertain whether similar equitability between the postal and email surveys would be achieved in these cases. We would therefore like to see more research into these issues to enable researchers, over time, to build up a better picture of non-response bias across a variety of different methods, countries, and contexts.

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